Education, Design and Practice – Understanding skills in a Complex World

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TEN YEARS OF BUILDING TECHNOLOGY AT CITY TECH: REFLECTIONS ON THE EVOLUTION OF FIRST YEAR BUILDING TECHNOLOGY COURSES IN AN OPEN ENROLLMENT CANDIDATE BARCH PROGRAM

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INTRODUCTION

Educating the architects of the 21st century requires reflection on the historical roots of pedagogy, analysis and integration of the application of best practices from the scholarship of teaching and learning, and creative development of new strategies that balance hard and soft skills development with critical thinking and creative problem-solving. A BARCH candidate program at New York City College of Technology (City Tech), an open enrollment CUNY college in Brooklyn, New York, offers a testing ground for innovative pedagogy that can achieve this balance while pursuing its mission to increase access to the discipline to a broader range of students. Emerging from a historically vocational culture, the building technology curriculum in particular at City Tech is a case study in the goal for balance between job readiness and critical skills-based education. Formally referred to as construction documents courses, the building technology courses are becoming dynamic laboratories for investigation that integrate with the design curriculum. They also incorporate history and theory to place discussion of structure, materials, tectonics, and performance into context. This paper reviews the experimentation and development of first-year building technology courses over a ten-year period at City Tech. Case studies of prominent buildings ranging from the Empire State Building to the Yale Center for British Art are presented as vehicles to provide a place-based laboratory and a historical/theoretical context for learning. Emphasis on three-dimensional explorations of structure and assemblies developed through hand drafting and digital modeling will be reviewed for their learning efficacy. Finally, assessment and improvement techniques for reading technical texts will be presented. These strategies are shown to be particularly useful for a diverse and often underprepared student cohort.

REFLECTION ON THE HISTORICAL ROOTS OF PEDAGOGY

Architectural education has inherent challenges stemming from the breadth of this discipline that seeks balance between science and art. The wide range of skills required to successfully practice outlined by Vitruvius in the ancient world are carried into the 21st century by registration and accreditation boards.[1] Schools of architecture, encouraged by NAAB to continuously improve, must periodically reexamine their pedagogy and curriculum to make adjustments that improve the facilitation of students' intellectual and personal growth and prepare them for a successful career in architecture or allied fields that continue to evolve with new approaches and technologies. This reexamination of pedagogy must recognize and respond to age-old challenges inherent in training and educating students of architecture precisely due to the breadth of the discipline, the role of young graduates in practice, and the preparation and skills required to advance in the profession for a successful life-long career.

The first formation of formal architectural education provides insight into the persistent emphasis on the hard skills in architectural education. Early programs such as the Mechanics Institute in New York served as training grounds to provide draftsmen to the emerging architectural profession of the 19th century in the United States, following an approach to pedagogy that today would be described as vocational.[2] The founding presentation of the first collegiate program at MIT in 1865 documents an approach to pedagogy that seeks educational efficiency and emphasis on hard skills at the sacrifice of exploration of the ideas of architecture, establishing an approach devoid of theory that is still characteristic of vocationally oriented programs. [3] Theory and the poetic exploration of architecture are left to the elite who have the luxury to explore these aspects of the discipline. This separation of the theatrical and practical continues in many programs to this day in the chasm separating technology and design education.

These same founding documents for MIT's program, however, discuss a more nuanced approach to architectural education that can feed into contemporary strategies to re-balance vocationally oriented pedagogy. The founding director William Ware outlines an approach that emphasizes learning by doing that is rooted in rigorous investigation of the materials and methods of construction following the scientific method, with observation and experimentation critical tools for learning.[4] This direct and intimate interaction with the material reality of architecture is consistent with a contemporary experiential, place-based, and inquiry-based learning approach that uses the built environment as a learning laboratory, moving critical activities outside the classroom. In this 19th presentation of architectural education we can see the kernels of approaches to educating job ready students that are engaged practitioners able to adapt and change with the discipline.

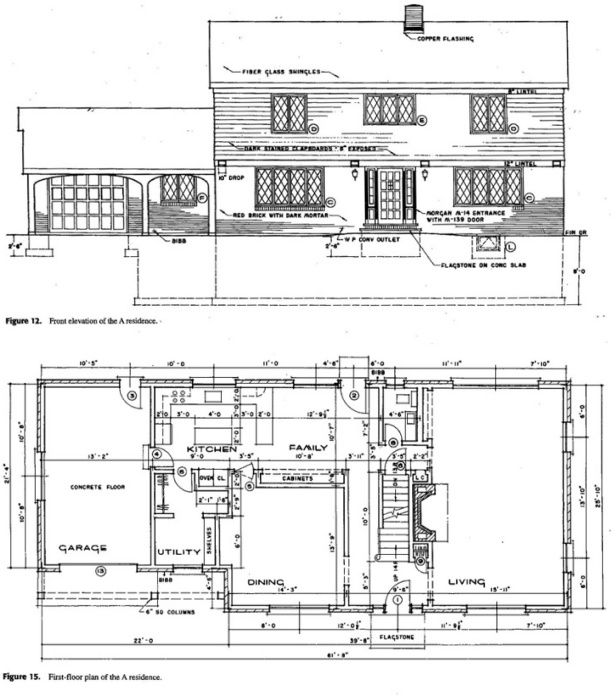

Figure 1. Elevation and plan of house for rote documentation assignment prior to course redesign, 2009.

TECHNICAL COURSES IN ARCHITECTURAL EDUCATION

The technical courses of many curricula around the country have persistent pedagogical roots in the vocational foundations of American architectural education, with a significant emphasis on digital tools for documentation. This emphasis is based on the view that documentation skills provide the smoothest and most time efficient pathway to entry level employment in the industry.[5] Vocational education still has relevance in the 21st century as demonstrated in countries like Germany, but it has limitations that become evident in the middle and late career of graduates of vocational programs. Studies indicate that degrees rooted in a general education core prepare graduates for greater career longevity through their adaptability to changing workplace and professional conditions.[6] Indeed employers in the 21st century emphasize in surveys the importance of critical thinking,[7] learning skills, and soft skills in the contemporary workplace.[8] Education scholarship increasingly supports inquiry and research as a critical approach to undergraduate pedagogy.[9] In the context of architecture baccalaureate degree programs with a general education mandate, technology courses can be reconceived to move beyond a pure focus on documentation skills to become dynamic studio-based laboratories for nurturing technical knowledge, critical thinking, and creative problem-solving skills. These courses also can be designed to break down the silo culture common in higher education by layering technological investigations with historical and theoretical perspectives.

The New York City College of Technology Department of Architectural Technology provides an illustrative case study of the transition of a vocationally oriented program serving associate degree students to a general studies baccalaureate degree program as well as an emerging undergraduate professional degree program.[10] In 2009, the department offered an associate's degree and a four-year technology degree. The associate degree at this time was heavily focused on technology education with six technical courses in the first year and at least another three in the second year. Of the six first-year courses, two focused on documentation (hand drafting), two on technical knowledge (materials and methods), one on digital drafting (AutoCAD), and one on site-planning. In 2009 the faculty of the department decided to reconsider this curriculum and to begin a process of realignment and integration of courses using NAAB's education requirements as the guide. In a major curriculum change, the two documentation courses and two materials and methods courses were combined with the digital documentation course to form two new technical studios, Building Technology I and II. The fundamental goal of the combination was to be able to link lecture-based material and drawing exercises but also to re-balance the design and technical content of the overall associate degree curriculum. Beyond this goal, these new courses allowed a significant shift from classroom based "knowledge acquisition" to courses where the technical knowledge is placed in historical and theoretical context, critical thinking skills are developed, and place-based inquiry is integrated.

ANALYSIS AND INTEGRATION OF BEST-PRACTICES FROM THE SCHOLARSHIP OF TEACHING AND LEARNING

The scholarship of teaching and learning is an important reference for the development of these new course outlines; in particular, three principles of teaching and learning are particularly relevant: prior knowledge, student motivation, and knowledge organization.[11] At the starting point of a first-year course, faculty need to be cognizant of the students' prior knowledge as effective learning is significantly impacted by the nature and extent of what students' know when they enter into the program. Further, students' motivation is important to how they learn, impacting the "direction, intensity, persistence, and quality of the learning behaviors in which students engage."[12] Also critical to the development of the course outlines is the consideration of how students organize knowledge. Experience is critical to the associations and connections students make between bodies of knowledge, and lack of experience in the discipline hampers effective mental organization of the new material

presented in the courses.[13] Each of these principles are addressed in the new courses. Prior knowledge is surveyed through the initial class discussions and a combination of reading and drawing assessments. Knowledge organization is made explicit through the integration of concept maps of the course content on the syllabus as well as scaffolded strategies for active reading note-taking through concept maps and graphic organizers. Student motivation is built through an emphasis on classroom engagement through active learning strategies as well as out of classroom exploration of the built environment focused on local iconic architectural works.

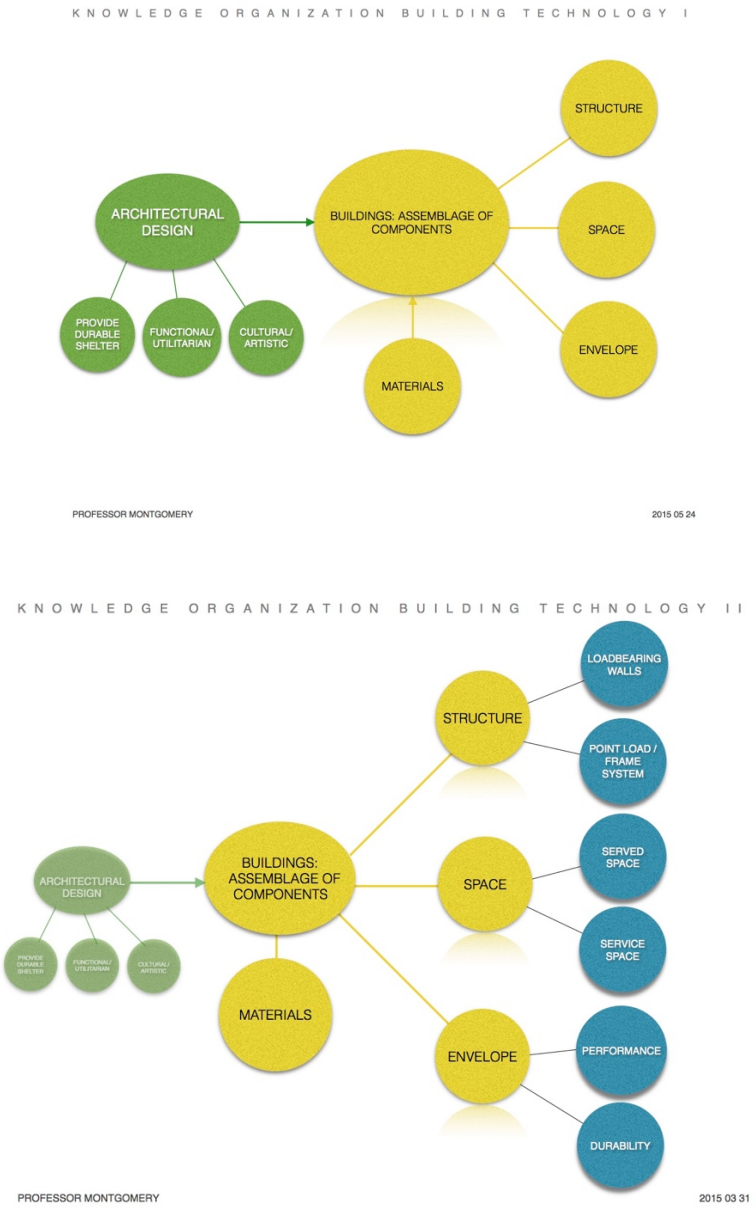

Figure 2. Knowledge Organization: Course content diagramed as concept maps, 2015.

Looking further into the scholarship of learning, strategies for deep and meaningful learning are integrated into the pedagogy of these courses. The lecture-based courses in 2009 focused primarily on

retention of information, while the new courses adopt strategies developed to foster the ability to *transfer* information.[14] In his research on learning, Richard Mayer links meaningful learning to constructivist learning, where students "engage in active cognitive processing, such as paying attention to relevant incoming information, mentally organizing incoming information into a coherent representation, and mentally integrating incoming information with existing knowledge."[15] Meaningful learning leading to problem-solving skills and critical thinking are central goals driving the development of these courses.

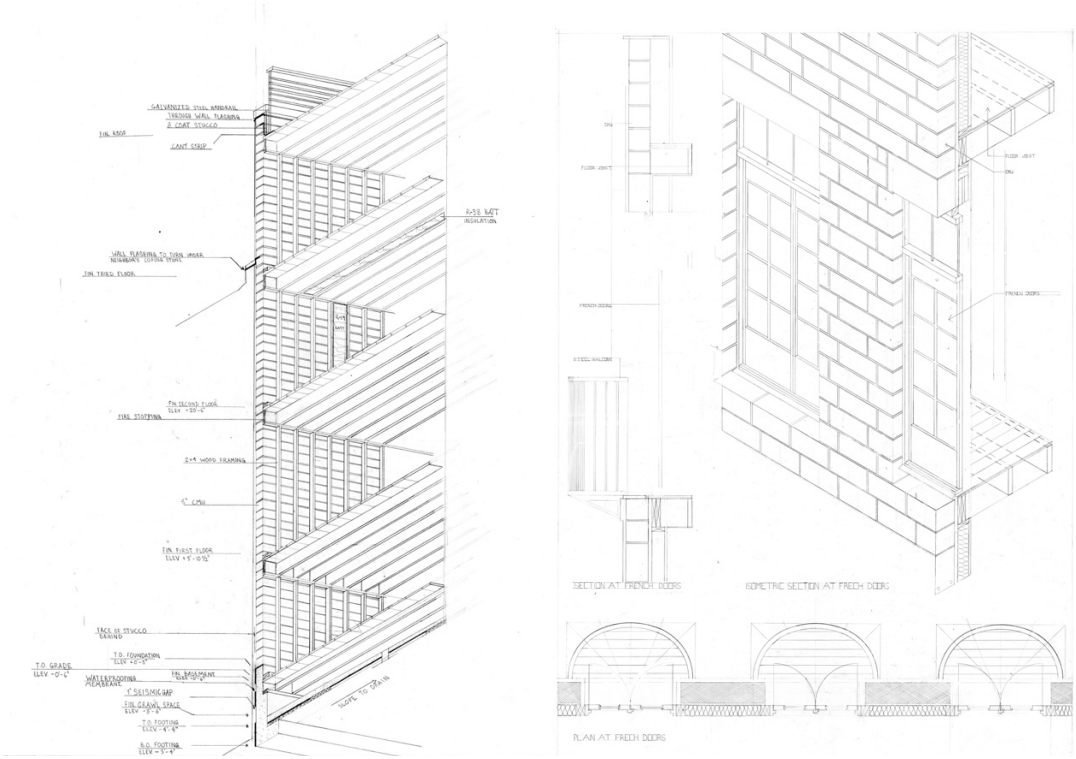

Figure 3. Student work after course redesign: three-dimensional studies of NYC townhouse, 2012.

EXPERIMENTING WITH METHODS FOR MEANINGFUL LEARNING: A CASE STUDY APPROACH

As a first step to developing this new pedagogy for the technical courses, an experimental learning community was organized that combined the first semester drawing course with the materials course. A case study strategy was developed for this course using the Empire State Building as the subject for investigation, chosen for its unique iconic position in New York City architectural heritage. It was also selected based on the information available to support student investigation, including the Lewis Hines photo documentation of the construction of the building. These construction photographs along with drawings made available at the Avery Library's Drawings and Archives Department allowed the students to reconstruct the layers of the building, learning about steel, stone and brick masonry, concrete, metal and glass, construction sequence, and the tectonics of the great 1930's tower. The investigation combined use of hand sketches, AutoCAD, SketchUp, and Revit modeling. The student studies embody learning through research and inquiry, with the process of investigation taking precedent over the product. A third-party review by a lead engineer from Thornton Tomasetti validated the level of engagement and investigation as well as the rigor of this process.

This experimental course demonstrated the potential for the use of a number of strategies in the curriculum. First, using case study buildings of significant historic or design value facilitate the learning behaviors promoted in the literature, including careful observation as a key to constructing knowledge, and analysis as a key to the development of critical thinking skills. The starting point for this case study was a series of site visits where students could use high resolution cameras and sketchbooks as tools for careful observation to initiate their analytical investigation. The case study also demonstrated the value of using buildings that have significant documentation to be used not for mere reproduction by the students but instead for the basis of investigation of structure, envelop, materials, and tectonics. Finally, the first-hand experience of seminal architecture is both a tool for motivation as well as establishing experiential knowledge foundations that can be built upon as the students mature.

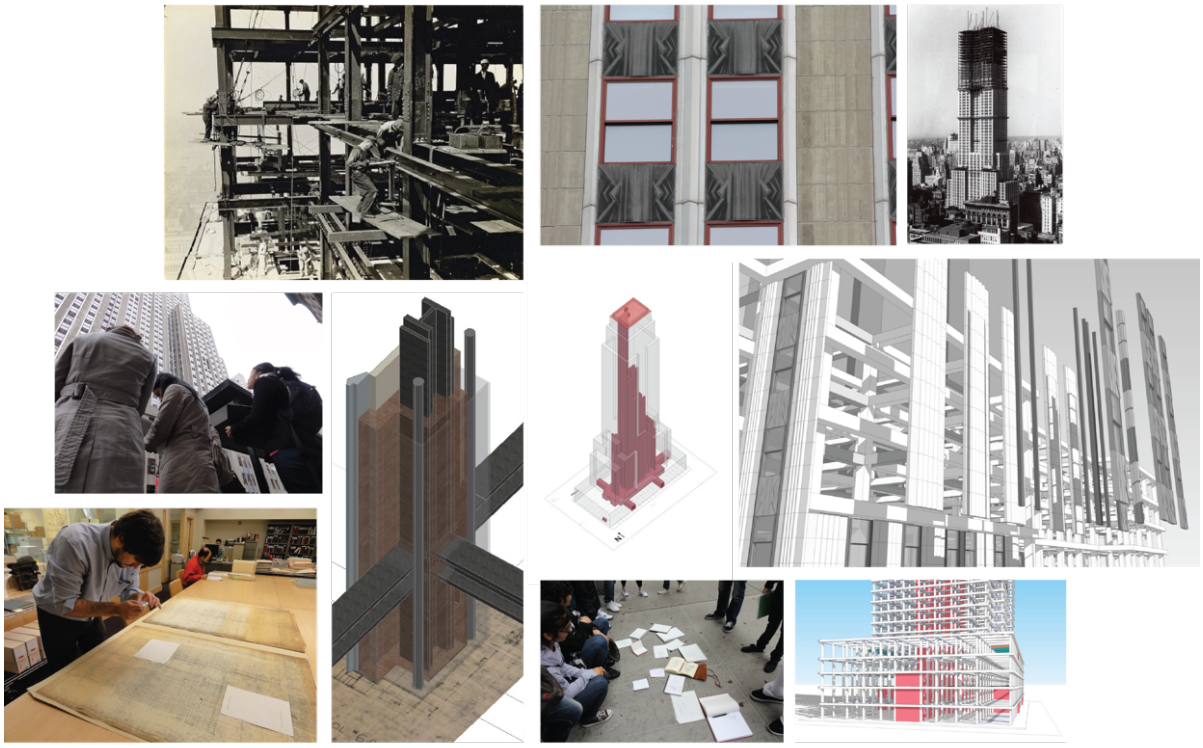

Figure 4. Empire State Building: Case study with inquiry as focus, 2011.

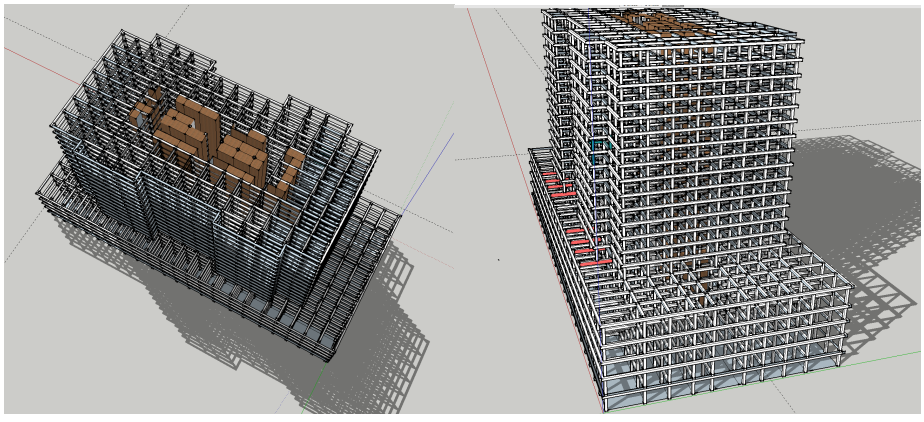

Figure 5. Study of structural frame and core, identifying locations of transfer beams, 2011

EXPERIMENTING WITH METHODS FOR MEANINGFUL LEARNING: DRAWING EXERCISES

Another experimental section tested strategies for development of specific drawing assignments and how these assignments could address the diversity of prior knowledge by filling in important gaps. Two assignments were tested to address the common faculty concern of a lack of rigorous understanding of geometry, mechanical drawing, scale, orthographic projection, drawing coordination, and drawing typologies.[16]

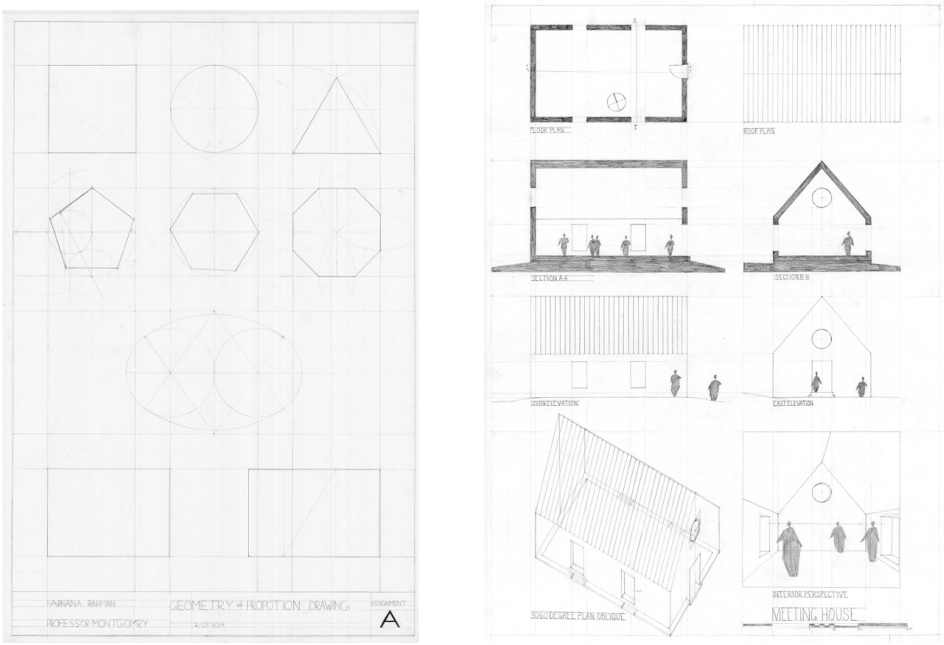

Figure 6. Initial drawing assignments responding to assessment of student prior knowledge.

In the 2009 drawing course that followed a rote vocational model, students reproduced a series of two-dimensional drawings provided in their handouts. In the experiment course, students used two-dimensional drawings as a basis for three-dimensional investigation of the volumetric nature of the building elements and their spatial relationship to each other. This approach was applied in both of the new first-year technical studios. For the latter course, the Yale Art Gallery was selected as the initial case study building. Here another critical curriculum strategy was introduced: the careful linkage of reading assignments and drawing investigations. The course maintained the existing text book, Allen and Iano's *Fundamentals of Building Construction*[17], but with the addition of Ching's *Building Construction Illustrated*[18] to support the three-dimensional visualization central to the new drawing investigations. The syllabus was crafted to lead the students through the course materials following the sequence of construction, from foundation to envelop, with each stage investigated with variable parameters to require problem-solving application of the knowledge gained through the reading materials and class discussions.

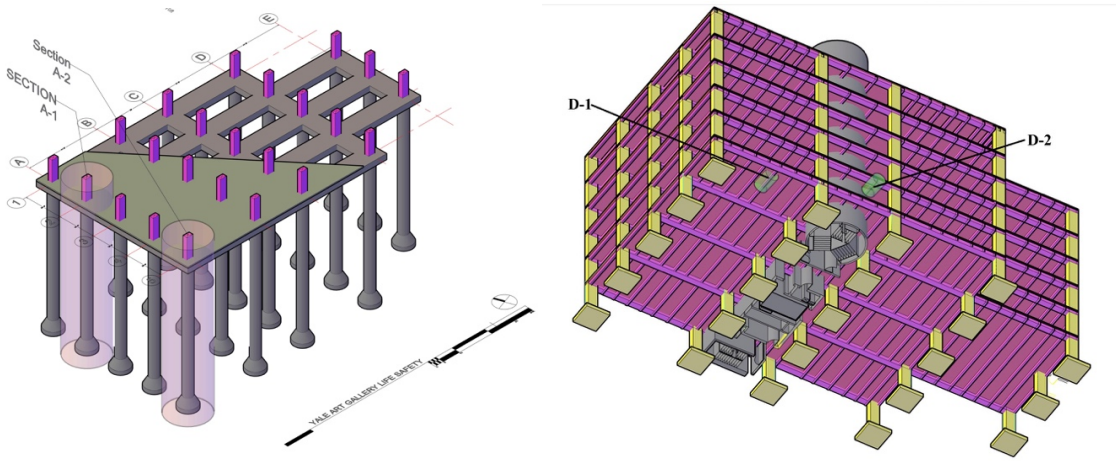

Figure 7. Student explorations of caisson foundations & one-way slab system using Yale Art Gallery as basis for application of technical concepts in course readings, 2012.

With digital tools introduced in the second semester, the assignments leverage the three-dimensional capability of these tools to study elements such as the concrete structural system or the window wall at high resolution. For elements like the building structure, the assignment asks the students to apply a selected system of structure to the case study building, considering the rules of thumb for the depth and spacing of elements based on the case study's structural spans and configuration. In this way, the student's work is moving beyond document reproduction and is constructing knowledge through application and problem-solving. Some of the critical elements of the Yale Art Gallery, such as the drum stair and window wall, were faithfully studied three-dimensionally to gain insight into Louis Kahn's elegant tectonic resolution of structure and form. In time both the Yale Art Gallery and the Yale Center for British Art were central case study buildings for this course. Each semester, a combined trip took students from all sections to New Haven for the day for the first-hand site investigation. For most of the students, this was a special day dedicated to the enjoyment and appreciation of the significance of architecture as a discipline, a quality particularly apparent through the mid-century modern works concentrated in New Haven.

Figure 8. Experiential + Place-based Learning: Exploring first-hand the tectonics of elegant design solutions, Yale Art Gallery, 2013.

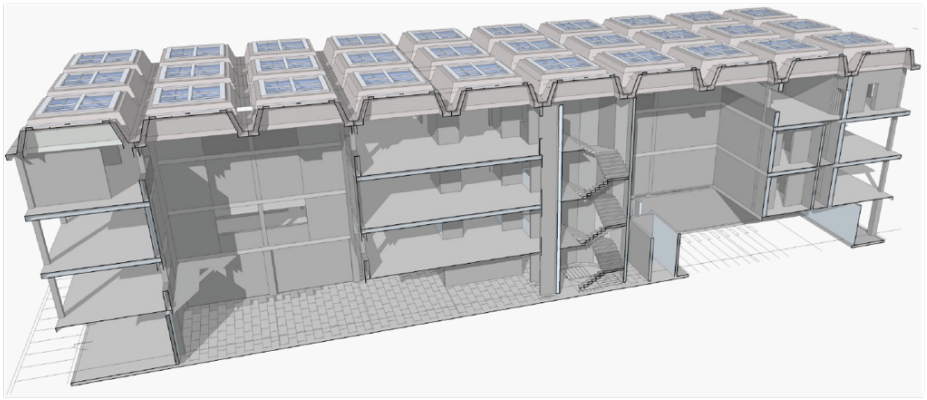

Figure 9. Student section study of Yale Center for British Art, 2014.

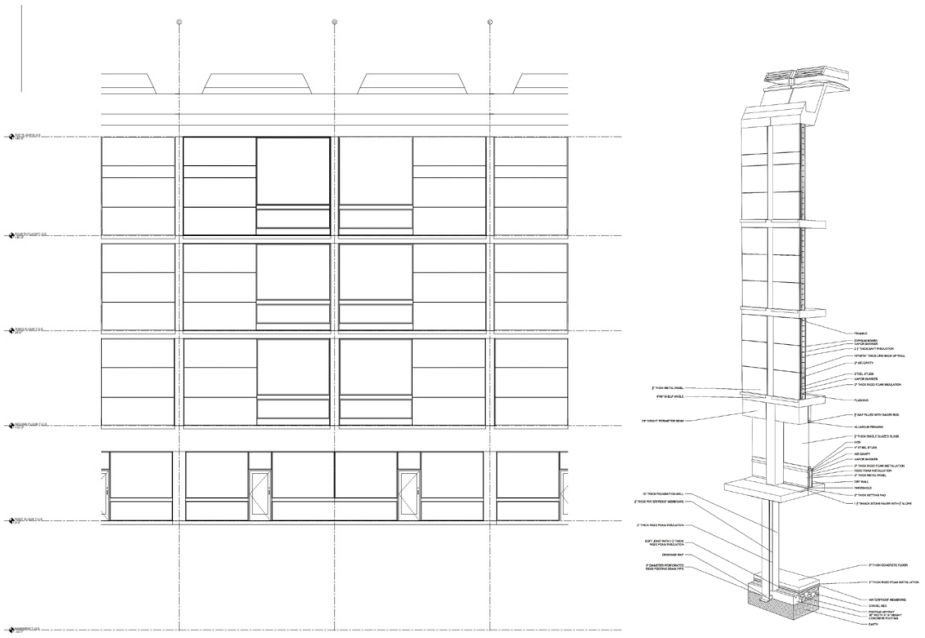

Figure 10. Understanding: Student study of exterior wall system, Yale Center for British Art, 2014.

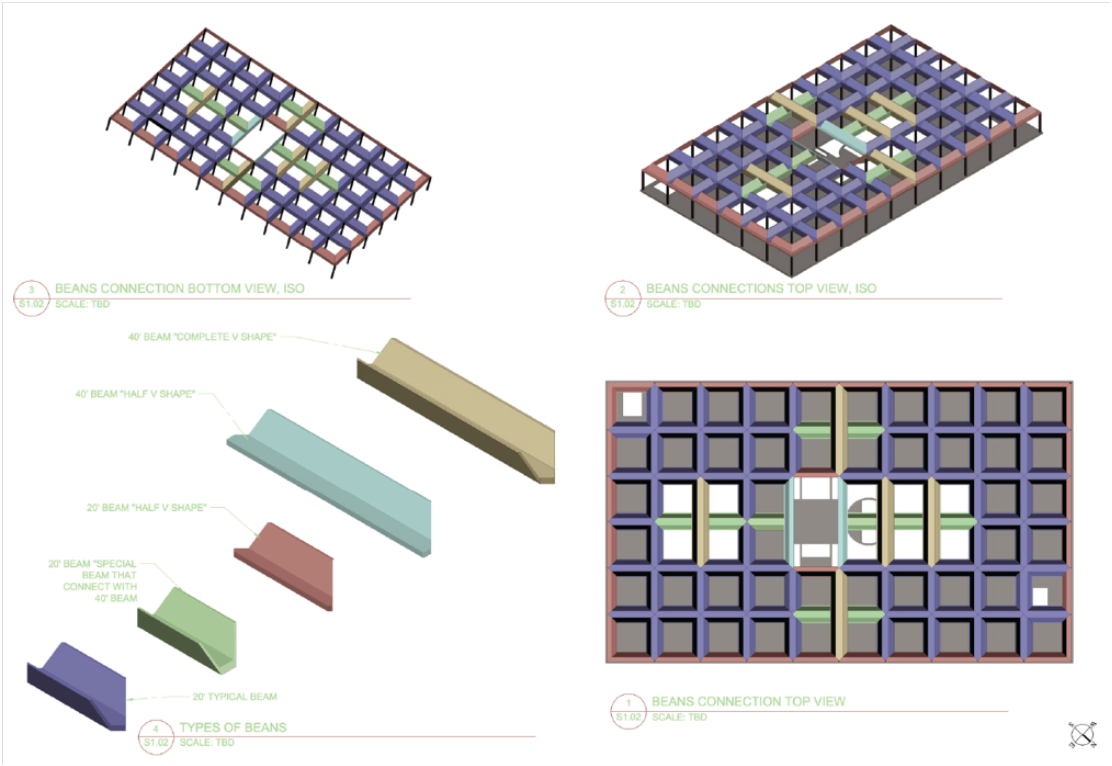

Figure 11. Analysis: Taxonomy of precast concrete beams, Yale Center for British Art, 2014.

One method of assessing the performance of students' meaningful learning is looking for evidence of higher order learning following a model like Bloom's Taxonomy. The Yale Center for British Art has served well to engage students to reach the higher levels as the building's remarkable subtleties challenge any observer to look more carefully. For example, the relationship and size of columns that looks relatively consistent in fact changes from one location to another. The students soon realize that a first level observation is not enough. Student attempts to accurately model the structural frame became an exercise in constant discovery and revision, activities promoted by the scholarship on meaningful learning and learning through inquiry.

Figure 12. Inquiry and Research: Student photographs of observations of condensation stains emitted from behind exterior metal panels and drip profile, Yale Center for British Art, 2014.

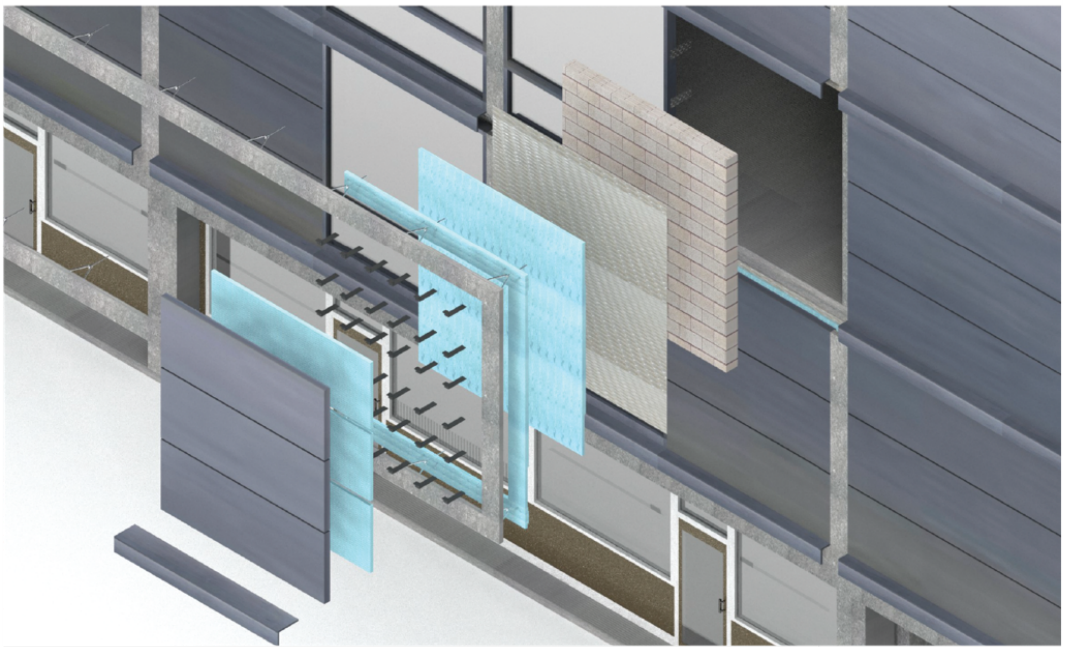

Figure 13. Research and Creative Problem Solving: Student proposal to solve condensation due to cold bridging in exterior wall, Yale Center for British Art, 2014.

CHALLENGES OF TEXT-BASED LEARNING

While the drawing assignments show strong evidence of higher levels of student achievement, the critical companion of learning technical knowledge through reading is a continued challenge. A reading assessment conducted in the spring 2012 raised the flag that our students struggle with reading effectively. This has sparked the participation of the building technology courses in the college wide READ program, which seeks to measure student reading each semester with pre and post assessments. This program provides faculty training to offer students reading improvement strategies and resources. This effort is showing signs of success, as the assessment results are improving. The central strategy implemented to improve student reading is a shift from weekly quizzes to submission of reading notes and to support reading engagement through off-campus discussions and experience of the built environment. Each student must submit their scanned, handwritten notes and sketches from each reading assignment and site visit. They are required to utilize both text and sketches for their notetaking.

This strategy has the great potential to bring the students face to face with their textbooks and to actually engage with them. Starting this past semester, students are also required to post a summary and reflection of each reading on the shared course site prior to the class on-site discussion. While these strategies are showing signs of success in actual reading effectiveness, the greater challenge of motivation remains. Students naturally show signs of greater dedication to their drawing investigations than their reading. While the drawing scores are steady, the reading scores drop off as the semester progresses. This assessment requires yet again another creative solution.

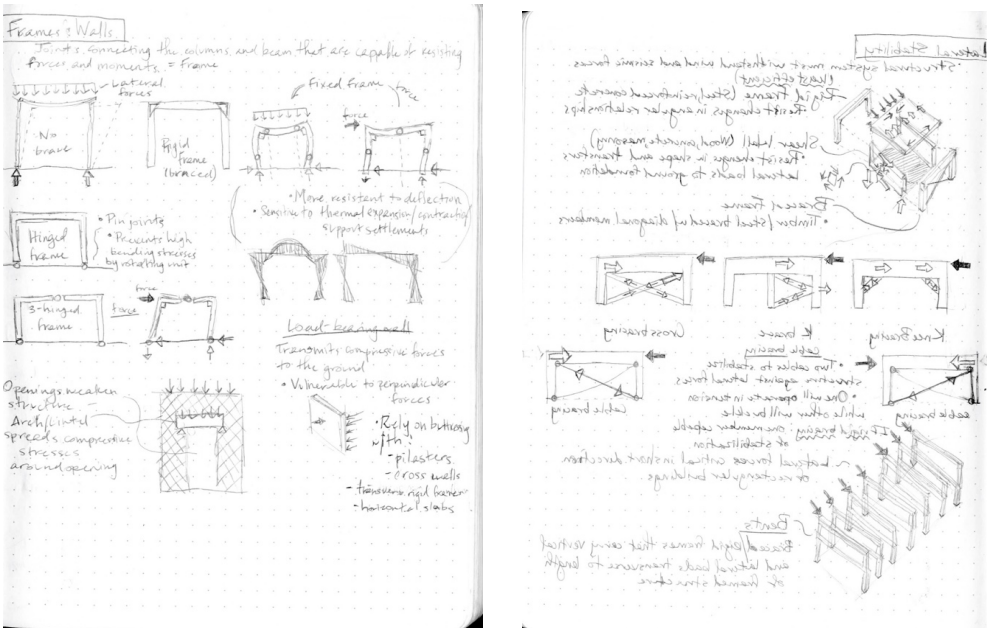

Figure 14. Sample of student notes, 2018.

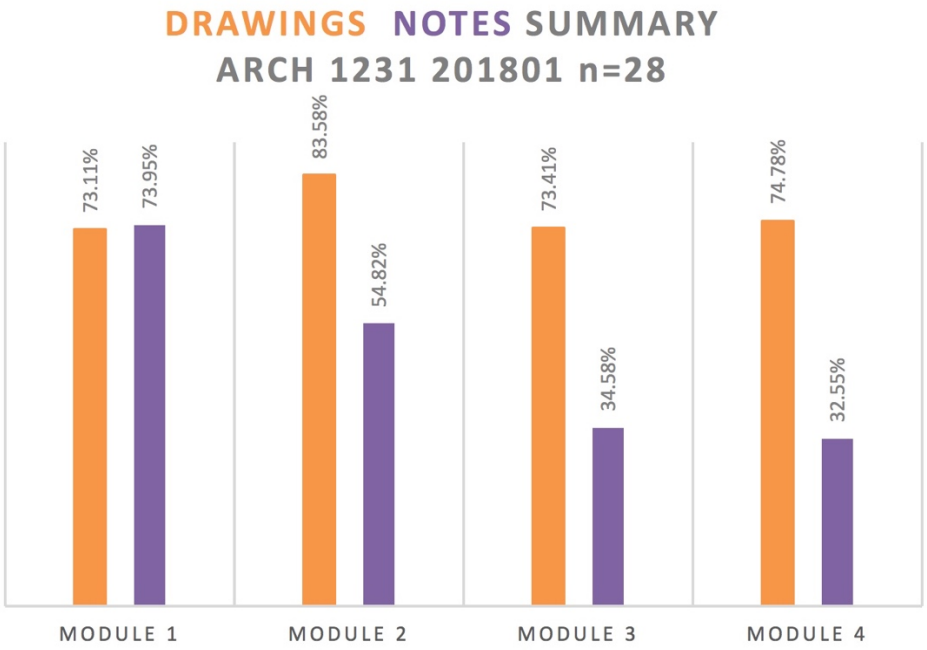

Figure 15. Passing scores for drawing assignments compared to reading assignments, 2018.

CONCLUSION / KEY FINDINGS

The continued refinement of these courses seeks an increasingly well-informed balance between the forces that drive job-readiness, including the tools of documentation, with the facilitation of critical thinking and creative problem-solving that foster a life-long learning ethos in the students. The evolution of these courses continues to this day, but the most important pedagogical innovations developed over the decade of experimentation continue to serve as the basis for teaching and learning. The key findings of this examination of a decade of course development are:

1. Emphasis on material and system investigation through three-dimensional drawings allows students to understand volume and relationships more clearly.
2. Linking assignments and reading material allows exploration, application, and practice, providing the increased opportunity for meaningful learning.
3. Assessing students' prior knowledge and continuously adjusting strategies and assignments accordingly provides foundational knowledge and skills for more effective learning.
4. Using New York City as a laboratory for teaching and learning, bringing students into first-hand contact with seminal architecture accomplishes the following:
    a. Provides the students with an increasing foundation of experience of architecture to improve knowledge organization across all courses in the degree program.
    b. Motivates the students towards engagement and dedication to learning.
    c. Facilitates meaningful learning through inquiry-based and experiential learning.
    d. Utilizes active strategies for teaching and learning that accommodates a variety of learning styles.
5. Text-based learning is a critical tool for building the skills employers require as well as facilitating life-long learning for each graduate. Faculty attention and support of student reading effectiveness is critical to the success of the students.

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[1] Vitruvius tells us that the architect should be a person " of letters, a skillful draughtsman, a mathematician, familiar with scientific inquires, a diligent student of philosophy, acquainted with music; not ignorant of medicine, learned in the responses of jurisconsults, familiar with astronomy and astronomical calculations." Frank Granger, trans., *Vitruvius On Architecture* (Cambridge: Harvard University Press, 1995), 9. In comparison, NCARB's Educational Standard[1] includes the categories of General Education, History and Theory and Human Behavior, Building Practices, Design, Professional Practice, and Optional Studies, while NAAB[1] requires evidence of student learning in the categories of Critical Thinking and Representation, Building Practices, Technical Skills and Knowledge, Integrated Architectural Solutions, and Professional Practice. From Vitruvius to NAAB, the individual seeking the professional title of architect needs to be a well-rounded practitioner with a broad education.
[2] George Barnett Johnston, "Drafting Manuals and Manual Training: Rouillion and Ramsey's Architectural Details," *Journal of Architectural Education* 58 (4):43, accessed June 8, 2019, doi: 10.1162/1046488054026732.
[3] William Ware, "An Outline of a Course of Architectural Instruction," (paper presented to the Society of the Arts of the Massachusetts Institute of Technology Dec 21, 1865), accessed June 8, 2019, https://libraries.mit.edu/archives/mithistory/pdf/architecture.pdf.
[4] Ibid. 14.
[5] Black Spectacles, Requirements for Working at the Top 50 Architecture Firms, https://archinect.com/news/article/104482643/do-your-homework-the-most-required-skills-to-work-at-the-top-50-architecture-firms

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[14] Richard E. Mayor, "Rote Versus Meaningful Learning," *Theory Into Practice* 41, no. 4 (2002): 226-32.
[15] Ibid. 227.
[16] This gap has increased with the demise of vocational courses in middle school and high school education in the United States as noted by Eric Hanusheck et. al.
[17] Allen, Edward, and Joseph Iano. *Fundamentals of Building Construction: Materials and Methods*. John Wiley & Sons, 2019.
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